

R<sup>3</sup>

# Rugged, Resilient Residences

Evan Mills

LBL • Residential Building Systems Group

Briefing for DOE Building Technologies Office

April 22, 2013

Resilient is not necessarily green ...  
... and green is not necessarily resilient





A ruined building is not a green building





# And there are limits to adaptation

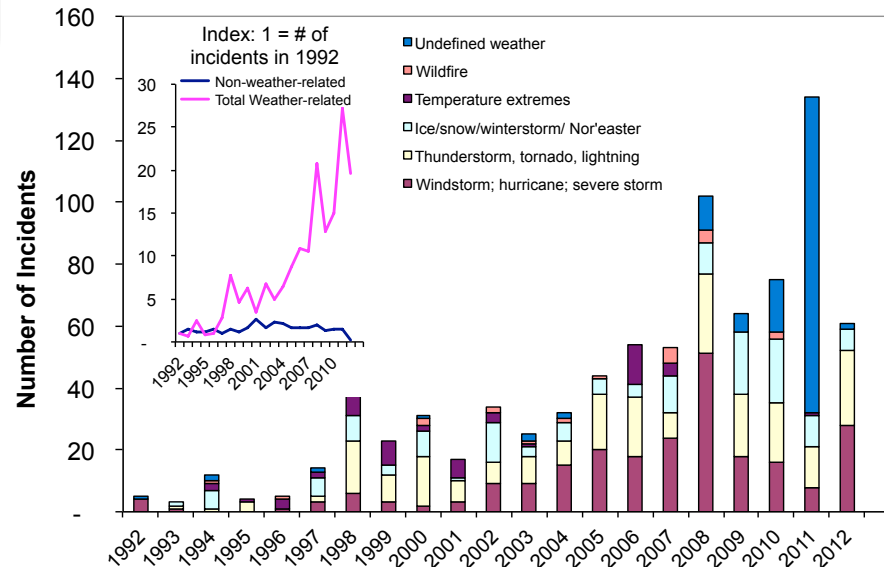




# Power outages are a cross-cutting concern



**Significant US Electric Grid Disturbances (1992-2012)**  
**1448 Weather-Related Incidents**



*Note: these are outages reported to EIA and not a full sample of all events.*

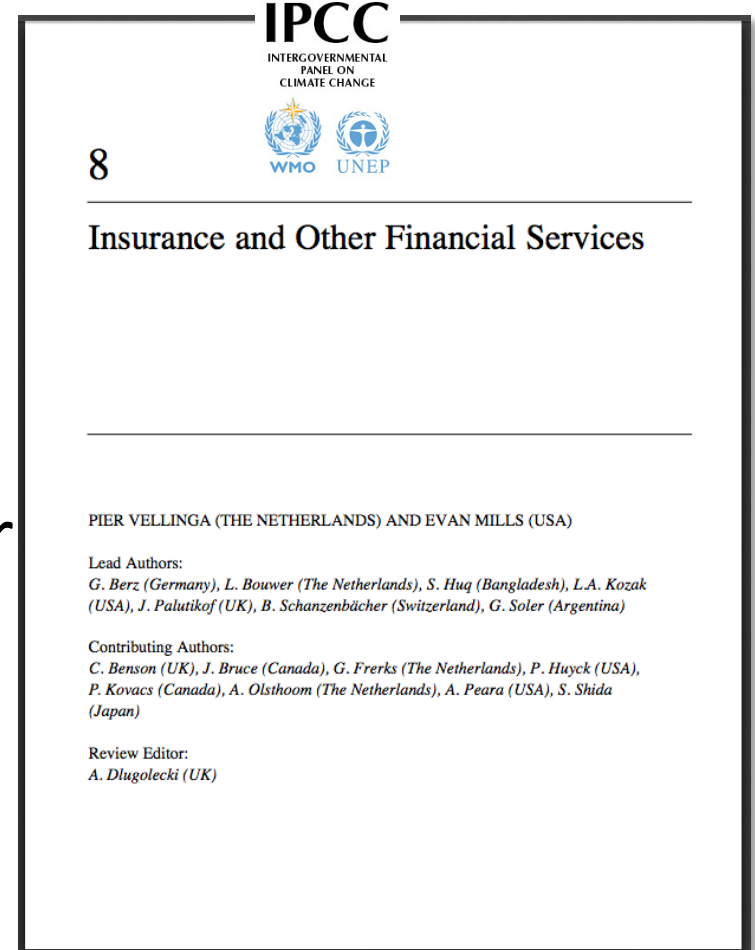




# Climate change makes matters worse

- Increased event frequency
- Increased event intensity
- Changing geography of exposures
- More complex impacts
  - (water > wind > fire>blackout)
- New challenges to the indoor environment
- Economic hardship (e.g., unaffordability or unavailability of insurance; lengthier business interruptions)

2001





# Considerations in thinking about roles for EERE technologies and practices

- The need for resilience extends beyond natural disaster situations, e.g., to small-scale events such as house fires, gradual deterioration of housing stock, etc.
- Costs are shouldered by a diversity of players
  - Consumers
  - Insurers
  - Public entities (federal/state/local)
  - ... and the “ROI” perspective is entirely different  
(think of the cost-benefit analysis on a backup generator)
- Measures can be interjected at various levels
  - Equipment
  - Envelope
  - Whole house
  - Neighborhood
  - Cityscape



# Downsides should not be ignored

- Solar panels blowing off rooftops
- Excessive complexity of measures => unreliability
- Inadvertently compromised IAQ
- Liability for underperformance
- Adaptations that cause energy use to increase (e.g., more AC), or water use (evaporative cooling)
- Insurers tend to over-think downside risks; but have at least proactively launched products to manage them

The screenshot shows the homepage of the PROPERTY CASUALTY 360 website. The header includes the site logo, a tagline "Together, we'll help keep California working.", and the URL STATEFUNDCA.COM. A navigation bar lists various categories: Home, Markets, Risk, Claims, Agent & Broker, Technology, Regional, Magazines, Directories, and eNewsletters. Below this, a secondary navigation bar lists specific topics: COMMERCIAL, E&S/SPECIALTY, LITIGATION, PERSONAL, REGULATION/LEGISLATION, REINSURANCE, WORKERS' COMP, and FEATURED LINES.

The main content area features an article titled "On Climate Change, a Do-Nothing Strategy is Not Risk-Free" by Evan Mills, dated March 13, 2013. The article discusses the complexities of climate change and the role of insurance. It mentions that beyond mitigating climate change, green technologies can even reduce conventional risks. It also notes that many insurers note that dual-paned windows are more fire-safe than single-paned ones (failing more slowly under heat stress, thereby helping block and keep down the supply of air to the fire). Pay-as-you-drive insurance helps reduce emissions from cars by rewarding reduced driving while lowering the probability of accidents. There is a long list of similar win-win strategies.

The article continues by stating that insurers are even finding that some strategies reduce emissions while helping directly fortify infrastructure against climate change impacts. Tokio Marine knows this, and has for over a decade been replanting mangrove forests across seven Pacific-rim countries for the dual purposes of pulling carbon-dioxide out of the atmosphere and reducing storm damages.

To do this right, insurers will want to look squarely at the whole constellation of responses to climate change and consider their comparative risks. There is a colorful cast of characters. Energy efficiency is arguably the most risk-free climate change response strategy. It doesn't hurt that it saves money as well. It mitigates risks such as vulnerability to forced power plant shutdowns during droughts and heat waves or weapons proliferation and fuel-import vulnerabilities posed by (mostly) carbon-free nuclear power. In fact, targeted efficiency makes the electric grid more robust and helps customers weather power outages.

Sadly, as proven methods of trimming emissions are delayed, concerned scientists and policymakers are increasingly looking to more desperate approaches such as "solar radiation management" by continuously dumping dust from high-altitude jets into the atmosphere or flinging trillions of reflective Pribbles into space (I kid you not) to block incoming solar energy, or dumping megatons of iron filings into the ocean to capture carbon in massive carbon-capturing algae blooms. These strategies are feared to usher in a variety of unintended side effects such as drought—not to mention fostering complacency. It will be interesting to see whether private companies proposing to conduct this work will be successful in obtaining insurance.

With burgeoning climate risks, a do-nothing strategy is of course not risk-free. The wisest response is to "greenline" emissions-reduction technologies rather than "redlining" them.

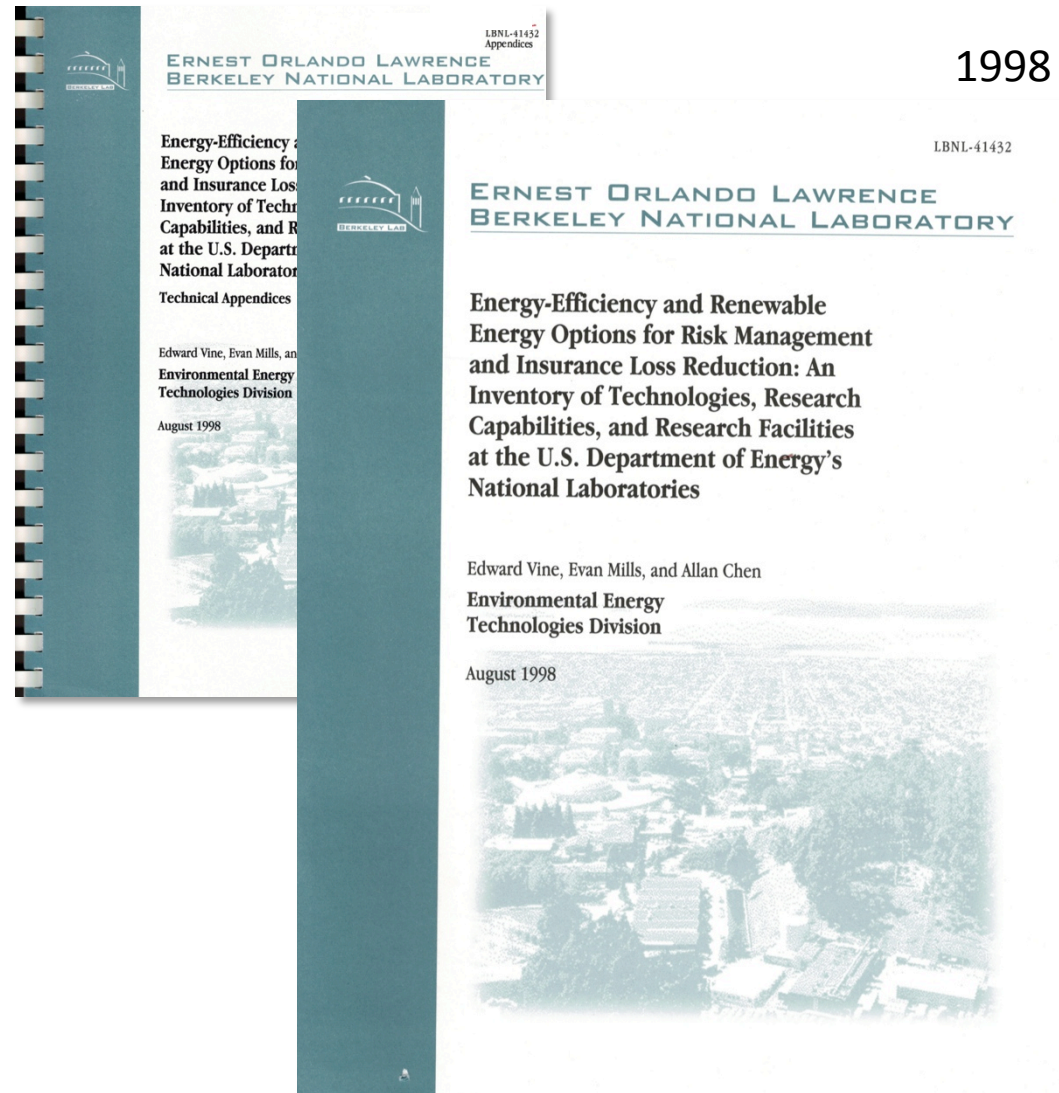
The article is followed by a section titled "ABOUT THE AUTHOR" featuring a photo of Evan Mills. Evan Mills is a scientist at the U.S. Department of Energy's Lawrence Berkeley National Lab, University of California. He received a Masters of Science degree from the Energy and Resources Group (where he is now a Research Affiliate) at the University of California at Berkeley in 1987 and a Ph.D. from the Department of Environmental and Energy Systems Studies under Thomas B. Johansson at the University of Lund in Sweden in 1991. Mills is a member of the international body of scientists which has worked under the Intergovernmental Panel on Climate Change (IPCC), which collectively shared in the Nobel Peace Prize for 2007 with former U.S. Vice President Al Gore.

The sidebar on the right contains a "STATE COMPENSATION INSURANCE FUND" logo with the tagline "Together, we'll help keep California working." Below this is a "RESOURCE LIBRARY" section with links to "Drive Business Growth with Financing from Oak Street Funding" and "Any Customer, Any Channel, Anytime: Building the Digital Insurance Enterprise...". There is also a "LOOKING FOR MARKETS?" section with a search bar and a "SOLVE YOUR PROBLEMS." section with a link to "Click for essential workers' comp info". At the bottom, there is a "TRENDING & MOST POPULAR" section with a link to "1. Best and Worst P&C Insurers for..."

*That said, risks of "EERE" technologies are far lower than those associated with other climate change responses*

# In the 1990s, at EERE's request, we explored potential roles for the insurance industry in mobilizing efficient and renewable technologies for enhanced resilience

- 9 National Labs
  - ANL
  - BNL
  - INEEL
  - LBNL
  - LLNL
  - NREL
  - ORNL
  - PNNL
  - SNL
- 50+ relevant assessment capabilities
- Findings
  - 78 technologies
  - 8 hazards
  - 15 types of insurance losses that can be mitigated





# We pursued a wider effort to engage with the insurance industry

2005

2012

Science  
AAAS

DEALING WITH DISASTERS  
VIEWPOINT

## Insurance in a Climate of Change

Evan Mills\*

Catastrophe insurance provides peace of mind and financial security. Climate change can have adverse impacts on insurance affordability and availability, potentially slowing the growth of the industry and shifting more of the burden to governments and individuals. Most forms of insurance are vulnerable, including property, liability, health, and life. It is incumbent on insurers, their regulators, and the policy community to develop a better grasp of the physical and business risks. Insurers are well-positioned to participate in public-private initiatives to monitor loss trends, improve catastrophe modeling, address the causes of climate change, and prepare for and adapt to the impacts.

Business and science meet in the wake of disasters. The insurance sector is a lightning rod, serving as global integrator of impacts across all sectors of the economy, and messenger of these impacts through the terms and price signals it projects to its customers (1). As the world's largest industry [it would be the third largest country if its \$3.2 trillion in yearly revenue were compared with national gross domestic products (GDPs)], the implications of rising disaster losses on insurers are as important as defining the industry's role in furthering understanding of the problem and advancing loss-prevention solutions.

The insurance "industry" is non-monolithic, with considerable regional variations in coverage, hazard exposure, and regulation within and among countries. Insurance penetration averages 9% of GDP (\$275/capita) in industrialized countries and 5% of GDP (\$25/capita) in developing countries and economies in transition (2). Although 12% of premiums today come from this latter market, at current growth rates it will constitute half of the global market within a few decades. Insurance payouts for weather-related disasters in the developing world are today three times the amount provided by international aid (3).

Insurance is part of a broader public-private patchwork for spreading risks across time, over large geographical areas, and among diverse social and commercial communities. Not all natural hazards are insured. In some cases (e.g., flood, crop), public and private agencies share the risk. The growing repository of insurance data—condensed among the best sources of disaster statistics (4)—augments geophysical observing systems with trends in economic impacts.

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The availability and affordability of insurance are vital for economic development and the financial cohesion of society, as well as security and peace of mind in a world where the knowledge of hazards lags their evolution. Unanticipated changes in the nature, scale, or location of hazards are among the most important threats to the insurance system. History has shown that society in general, and insurers in particular, are often caught unprepared for ostensibly "inconceivable" disasters. This reflects,

human losses for single events rather than for entire insurance "seasons." The limitations of this approach were evident in the 2004 U.S. hurricane season and its \$60 billion in economic losses (of which half were insured).

The weather-dependent share of global insured catastrophe losses (~90%) is greater than that experienced by the economy as a whole (~75%) (Fig. 1). This, coupled with the increase in the number, cost, and variability of such losses (Fig. 2), has brought some insurers, reinsurers, and their trade associations to view climate change as a strategic factor in their future (5-8).

Virtually all segments of the industry have a degree of vulnerability to the likely impacts of climate change, including those covering damages to property (structures, automobiles, marine vessels, aircraft), crops and livestock; pollution-related liabilities; business interruptions, supply-chain disruptions, or loss of utility service; equipment breakdown arising from extreme temperature events; data loss from power surges or outages; and a spectrum of life and health consequences (9).

Specific technical risks include the following: (i) Shortening times between loss events. (ii) Changing absolute and relative variability of losses. (iii) Changing structure of types of events. (iv) Shifting spatial distribution of events. (v) Damage functions that increase exponentially with weather intensity (e.g., wind damages rise with the cube of the speed). (vi) Abrupt or nonlinear changes in losses. (vii) Widespread geographical simultaneity of losses (e.g., from tidal surges arising from a broad die-off of protective coral reefs or disease outbreaks on multiple continents). (viii) More single events with multiple, correlated consequences. This was well evidenced in the pan-European heat catastrophe of 2003—where temperatures were six standard deviations from the norm (9). Immediate or delayed impacts included extensive human morbidity and mortality, wildfires, massive crop losses, and the curtailment of electric power plants owing to the high temperature or lack of cooling water. (ix) More hybrid events with multiple consequences (e.g., El Niño–Southern Oscillation (ENSO)-related rain, ice storms, floods, mudslides, droughts, and wildfires).

Specific market-based risks include the following: (i) Historically based premiums that

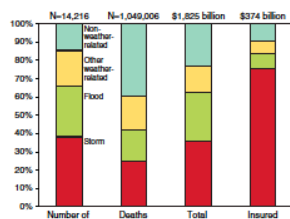


Fig. 1. Global impacts of natural disasters from 1980 to 2004. Insured property losses are dominated by storm events due to risk-selection preferences of insurers and coverage of flood and crop exposures by public entities, and low penetration of earthquake insurance. Economic values are inflation-adjusted to 2004 levels. [Source: Munich Re, NatCatSERVICE]

in part, the recurring social miscalculation of using the past to predict the future while underinvesting in disaster preparedness. Be it the attacks of "9/11" or Hurricane Andrew, expectations based on past experience led to complacency and dramatic underestimation of exposure. An eye-opening insurance industry report from the mid-1980s (5) highlighted the importance of anticipating multiple large events in a single year, yet exposures are still often expressed in terms of probable maxi-

CLIMATE CHANGE

## The Greening of Insurance

Evan Mills

Every sector of the economy telegraphs climate risks to its insurers. In turn, climate change stands as a stress test for insurance, the world's largest industry, with U.S. \$4.6 trillion in revenues, 7% of the global economy (1-6). Insurers publicly voiced concern about human-induced climate change four decades ago (7). I describe industry trends, activities, and promising avenues for future effort, from a synthesis of industry progress in managing climate change risk [see supplementary materials (SM)].

Increasingly, multifaceted weather- and climate-related insurance losses involve property damage, business disruptions, health impacts, and legal claims against polluters. Worldwide, insured claims that were paid for weather catastrophes average \$50 billion/year (about 40% of total direct insured and uninsured costs); they have more than doubled each decade since the 1980s, adjusted for inflation (7, 8). Insurers must also adjust to risks emerging from society's responses to climate change, including how structures are built and energy is produced.

Where there are risks, there are also opportunities. Responding to the push of shareholders and regulators and the pull of markets, a trio of global initiatives (United Nations Environment Programme Finance Initiative (1995), Climate Wise (2007), and the Kyoto Statement (2009)) has aggregated 129 insurance firms from 29 countries (table S1). Member commitments include supporting climate research, developing climate-responsive products and services, raising awareness of climate change, reducing in-house emissions, quantifying and disclosing climate risks, incorporating climate change into investment decisions, and engaging in public policy. Since the mid-1990s (3), these and many other insurers, reinsurers, intermediaries, brokers, industry associations, catastrophe-loss modelers, and regulators have engaged in this work (see the figure) (fig. S1, A to C), often in partnership with universities, development agencies, nongovernmental organizations, foundations, think tanks, and governments (9). These increasingly sophisticated efforts were sustained through the economic malaise of the past few years; one-fifth of the activities identified in the figure began after 2008.

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**Climate Science, Adaptation, and Mitigation** As past experience is an ineffective predictor of future losses, many insurers are using climate science to better quantify and diversify their exposure, more accurately price and communicate risk, and target adaptation and loss-prevention efforts (table S2). Insurers also analyze their extensive databases of historical weather- and climate-related losses, for both large- and small-scale events (7-11). Insurers from North America, Asia, and Europe have expanded their collaborations through the three latest Intergovernmental Panel on Climate Change assessments into projects such as harmonizing economics-based insurer catastrophe models with climate models. Insurers' models extrapolate historical data rather than simulate the climate system, and they require outputs at finer scales and shorter time frames than climate models.

Insurers can reactively adapt to rising losses by tightening availability, prices, and terms. Instead, some have sought to help vulnerable customers improve their resilience to a changing climate. Strategies include financial and physical risk management, often in collaboration with noninsurance entities (table S3). Insurers have championed a broadened definition of sustainability that includes resilience to disaster and a low carbon footprint. Beyond signaling that loss-prone development is unsustainable, insurers are supporting interventions with benefits for both emissions reduction and adaptation (table S4 and fig. S2). Integrated actuarial and environmental science is enhancing adaptive capacity to climate change in the developing world, where poor populations enjoy little access to insurance. Decades ago, public and nonprofit sectors offered microinsurance (small premiums for modest coverage), with commercial insurers later adding tens of millions of policies for life, health, and property (table S5). Some employ parametric and index-based triggers for climate-sensitive crops and livestock by using remote sensing. Others promote adaptation, e.g., improved soil management.

Numerous insurers aim to curb greenhouse-gas emissions from homes, businesses, transport, industry, and agriculture (table S5). They have brought to market at least 130 products and services for green buildings. Many pay claims that fund rebuilding to a

Insurance industry trends show how market-based mechanisms support climate change mitigation and adaptation.

higher level of energy efficiency after losses. Insurers have introduced at least 65 offerings for renewable energy systems.

Some climate-change mitigation technologies align with lower-risk behavior. Nearly 3 million pay-as-you-drive policyholders enjoy more accurate roadway accident premiums using telematics to verify distances driven. This price signal could reduce U.S. driving by 8%, worth \$50 to \$60 billion/year, thanks to reduced congestion and lower probability of accidents, while reducing cross-subsidies from those who drive less than average to those who drive more (12). Risk-based premium credits are also offered for low-emissions vehicles and green buildings (table S5).

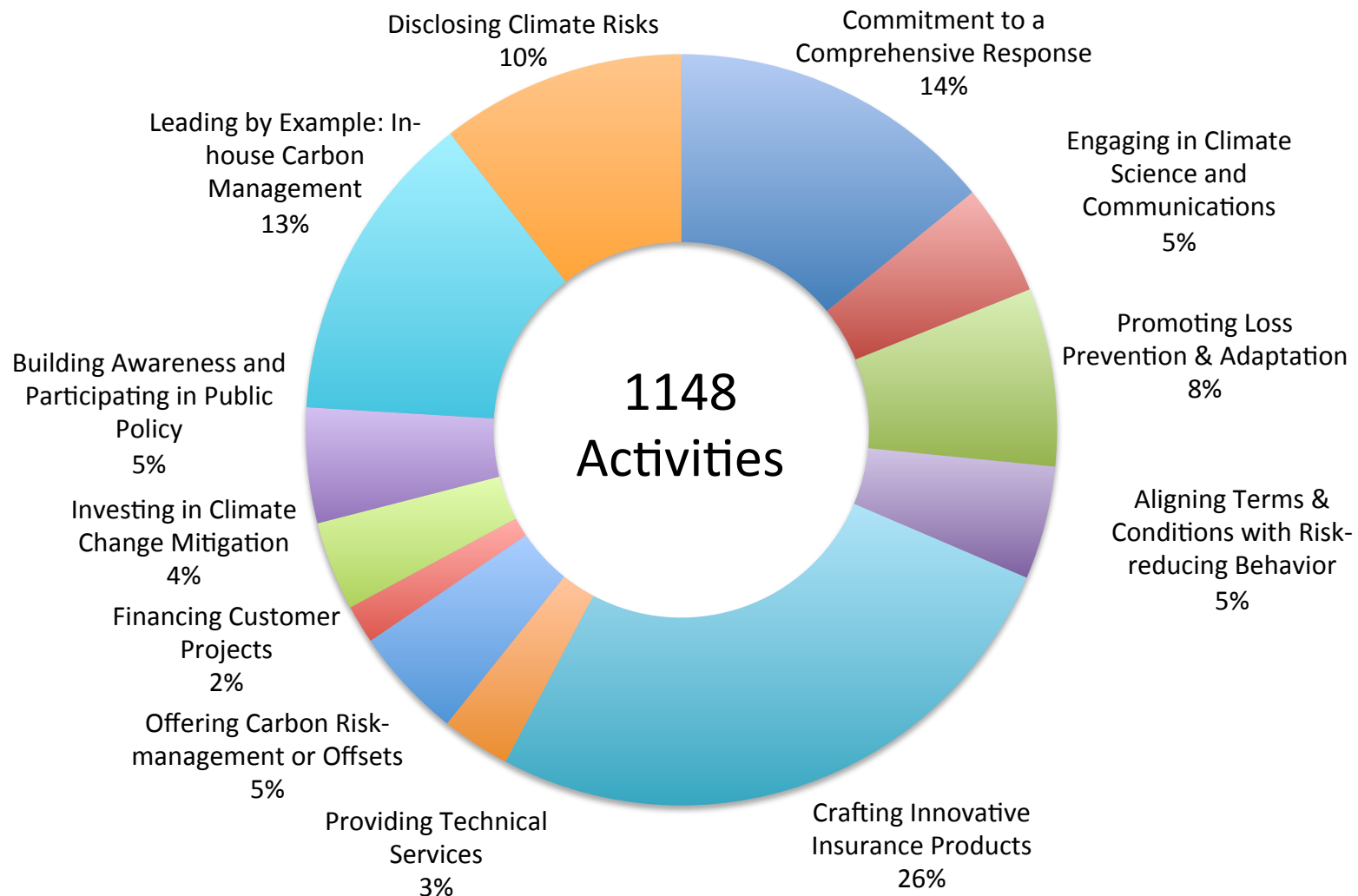
Other products insure financial shortfalls if energy savings or low-emissions power generation projects underperform or manage risks in carbon-trading transactions, ranging from carbon release from wildfires to infrastructure appropriation by foreign governments. Insurance strategies assuming these risks and minimizing losses align with the broader policy objectives of verifiable, bankable, and persistent emissions reductions.

### Technology, Governance, and Policy

When risks are too great or undefined, insurers withdrew coverage or increase prices. Climate change mitigation and adaptation present dual challenges in this regard: unintended risks (e.g., nuclear power and weapons proliferation) and climate vulnerabilities (e.g., biofuels and water needs) (tables S6 and S7). Insurers abhor unquantified and unpriced risks, as well as market distortions, such as equally subsidizing technologies that have divergent risk profiles (13).

Emerging technologies lack the operational history desired for underwriting. The most unwieldy of these are "climate-engineering" techniques, ranging from carbon capture and storage (CCS) to artificially modifying the radiative properties of the atmosphere. Insurers have entered the CCS market in a circumscribed manner, excluding riskier strategies or financial arrangements, limiting coverage to short time frames, and ceding long-tail risks to the public sector. Conversely, energy efficiency is arguably the lowest-risk mitigation strategy (followed by renewables), with abundant benefits (14). Societal dithering forces reliance on approaches that are riskier and less amenable to insurance underwriting.

# We identified and tracked a remarkable level of insurer engagement, globally







## Resilience-Efficiency Co-benefits ?



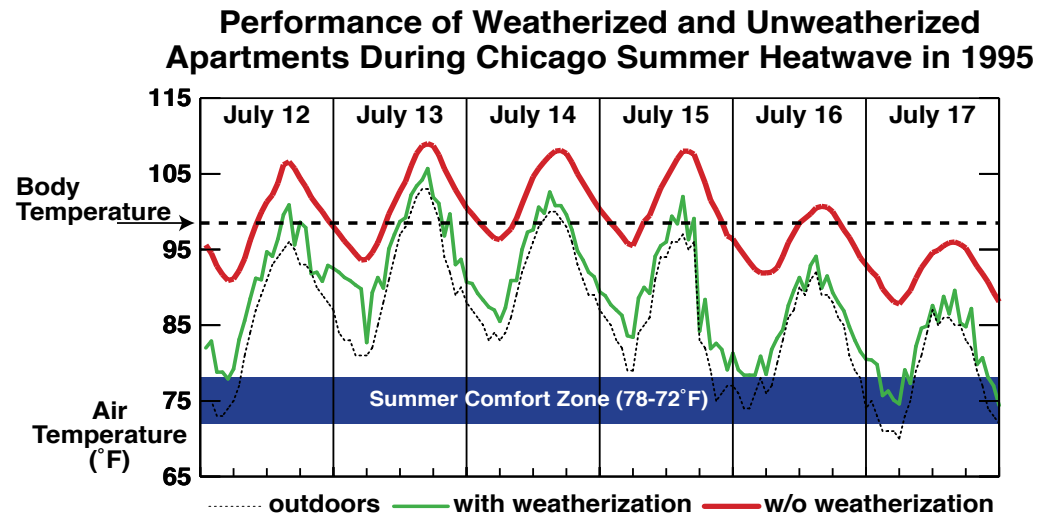
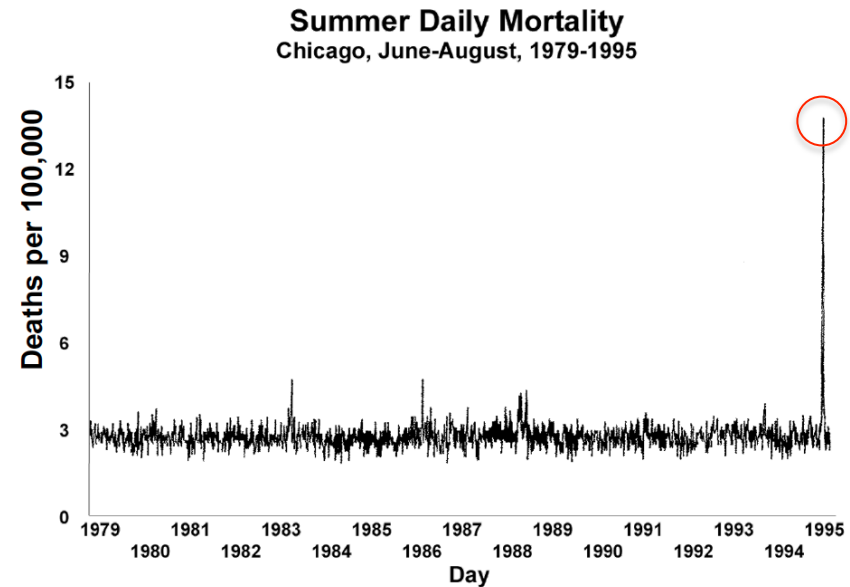
# Framework & examples

	Reducing Physical Damages & Injury									
	Fire entry from outside	Fire genesis inside	Earthquake damage	Wind-damage	Moisture damage	Perished footstuffs	Heat illness or mortality	Cold extremes	Ice Dams	Outdoor air quality
Air-sealing		x			x					x
EE windows	x					x	x			
Water pipe insulation				x			x			
Efficient envelope							x	x		
Cool roof						x				
HRV							x			
Efficient lighting / battery backup								x		
Shading						x				
Closed-cell insulation			x	x	x					
Passive solar space conditioning and cooling		x								
Solar DHW		x								
Efficient refrigeration					x					
Water-efficient appliances and fixtures										
PV grid-intertie bypass										
House-integrated EV battery										



# 1. Heat mortality: Chicago 1995

- Risk
  - Heat is #1 extreme-weather killer in US
  - People often die because of conditions inside homes
- Solutions
  - Improved thermal integrity
  - Cool roofing
  - Natural ventilation



Analysis by Joe Huang, LBNL

## 2. Ice dams

- Risk
  - Heat loss melts rooftop snow, refreezing at cold eaves and causing water intrusion
- Solutions
  - Improve insulation
  - Reduce air leakage
  - Eliminate bypasses
  - Reduce duct losses
  - More efficient recessed lights



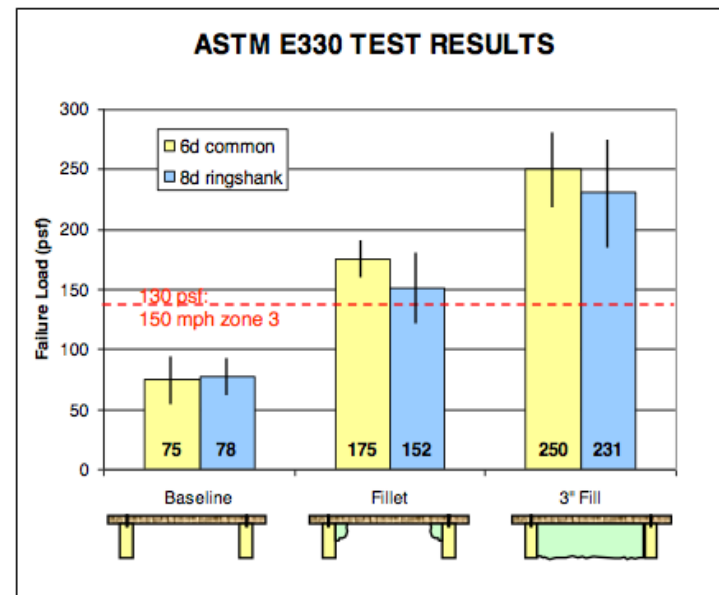


# 3. Roof failure in windstorms

- Risk
  - Roof deck failures are leading cause of residential building loss in hurricanes
- Solutions
  - Closed-cell foam for improved adhesion



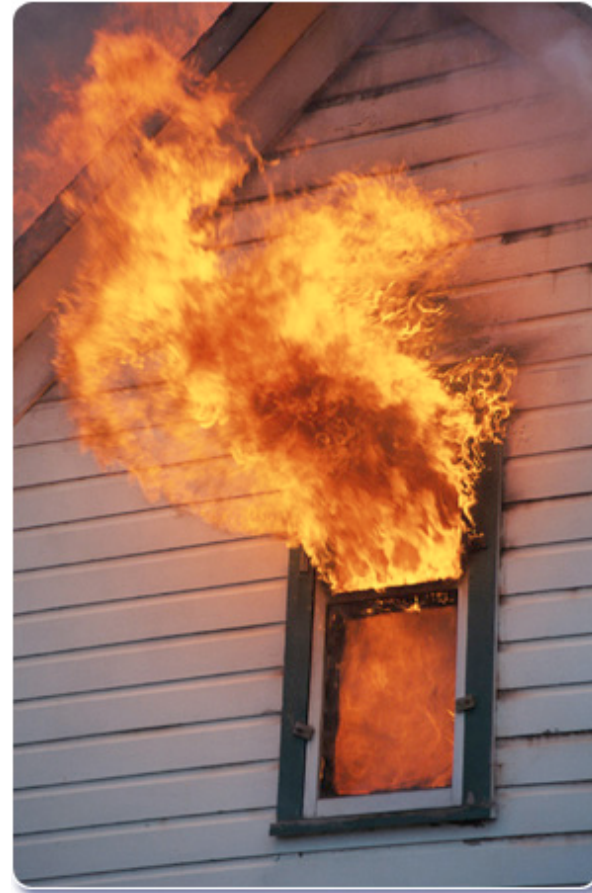
Houses with damaged or missing roof sheathing in Florida



University of Florida, International  
Hurricane Research Center

# 4. Fire and glazing systems

- Risk
  - Failure of window in fire is big correlate of damage extent
- Solutions
  - Multi-pane systems shown to fail more slowly due to heat stress under fire
  - Tests by Pilkington (Sweden) found 2-glazed, low-e systems to take 3-4x longer to fail under fire than 2-glazed alone (?!)



# 5. Fire and halogen lighting

- Risks
  - Circa 1995, the popularity boom of halogen torchieres was associated with hundreds of structural fires
  - Lamp temperatures ~1000F
  - Insurers turned to LBNL for ideas
- Solutions
  - CFLs eliminated the heat source (and saved energy).
  - CFL torchieres became popular with risk managers responsible for university dormitories. Fire risks spurred RD&D





# Keystone concept: Sheltering in Place

- The ability to shelter in place includes not only averting physical damage, but also:
  - Electronic communications
  - Comfort
  - Moisture protection
  - Evening illumination
  - On-site water
  - Active refrigeration
  - Sump pumps
  - Alarm systems

*Most of these have to do with energy services. Standard “supply side” response is to buy a generator. Issues: cost, safety, reliability, fuel availability/viability, pollution*

# Framework & examples

Reducing Physical Damages & Injury										
	Fire entry from outside	Fire genesis inside	Earthquake damage	Wind-damage	Moisture damage	Perished footstuffs	Heat illness or mortality	Cold extremes	Ice Dams	Outdoor air quality
Air-sealing		x			x					x
EE windows	x					x	x			
Water pipe insulation					x		x			
Efficient envelope							x	x		
Cool roof						x				
HRV							x			
Efficient lighting / battery backup								x		
Shading						x				
Closed-cell insulation			x	x	x					
Passive solar space conditioning and cooling		x								
Solar DHW		x								
Efficient refrigeration					x					
Water-efficient appliances and fixtures										
PV grid-intertie bypass										
House-integrated EV battery										

# Shelter-in-place applications

*Irrespective of backup power source, energy efficiency across all end uses (particularly critical ones) extends time that services can be maintained.*

	Reducing Physical Damages & Injury										Services / Shelter-in-Place
	Fire entry from outside	Fire genesis inside	Earthquake damage	Wind-damage	Moisture damage	Perished footstuffs	Heat illness or mortality	Cold extremes	Ice Dams	Outdoor air quality	Need to evacuate home (Shelter in-place)
Air-sealing		x			x					x	x
EE windows	x					x	x				x
Water pipe insulation					x		x				x
Efficient envelope							x	x			x
Cool roof						x					x
HRV							x				x
Efficient lighting / battery backup								x			x
Shading						x					x
Closed-cell insulation			x	x	x						x
Passive solar space conditioning and cooling		x									x
Solar DHW		x									x
Efficient refrigeration					x						x
Water-efficient appliances and fixtures											x
PV grid-intertie bypass											x
House-integrated EV battery											x

*15k house fires each year are caused by candles, ~30% of which occur during power outages* 21



# Off-grid power while sheltering in place

HOME PAGE TODAY'S PAPER VIDEO MOST POPULAR U.S. Edition ▼

**The New York Times**  
Friday, March 29, 2013

**Environment**

WORLD U.S. N.Y. / REGION BUSINESS TECHNOLOGY SCIENCE HEALTH SPORTS OPINION

ENVIRONMENT SPACE & COSMOS

Investments | Insurance | Retirement [Learn](#)

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## Green


**A Blog About Energy and the Environment**

December 23, 2008, 9:58 am

### Prius: It's Not Just a Car, It's an Emergency Generator

By KATE GALBRAITH

The Prius has a new use, and it does not involve driving. [The Harvard Press](#) — which serves the Massachusetts town of Harvard as opposed to the university — [reported](#) that the car's battery helped keep the lights on for some locals during the recent ice storms.



The newspaper reports that John Sweeney, a resident who lost power, "ran his refrigerator, freezer, TV, woodstove several lights through his Prius, for days, on roughly five gallons of gas."

## Automotive News

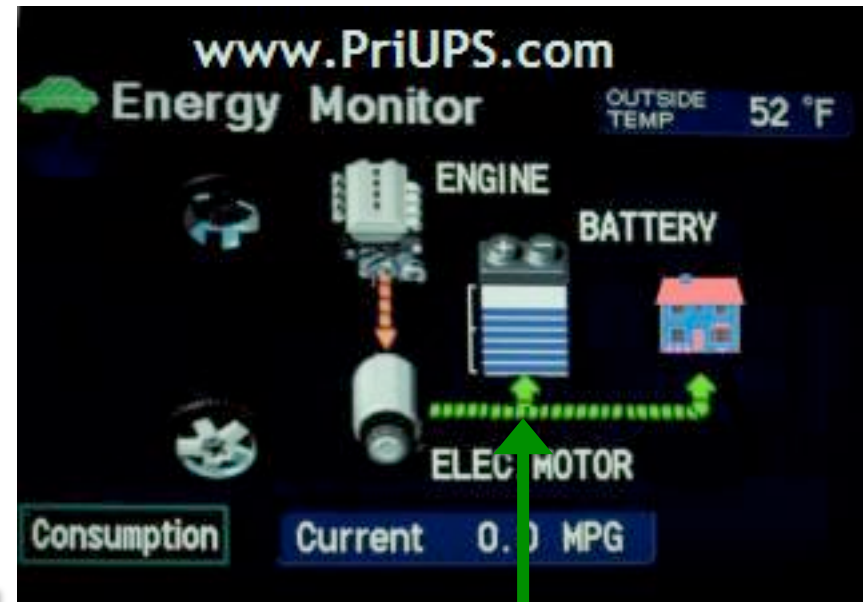
### Toyota to begin offering AC outlets on the Prius in Japan

Hans Greimel -- Follow Hans on [Twitter](#)  
Automotive News | July 19, 2011 - 9:01 am EST

SENDAI, Japan -- How's this for a more user-friendly hybrid?

Next year, Toyota Motor Corp. will start offering AC electric outlets as an option on its popular Prius hybrid so drivers can plug in household appliances -- from computers to refrigerators.

The idea was born from watching victims of Japan's March 11 earthquake using the Toyota Estima hybrid van as a source of emergency electricity when the power was knocked out.

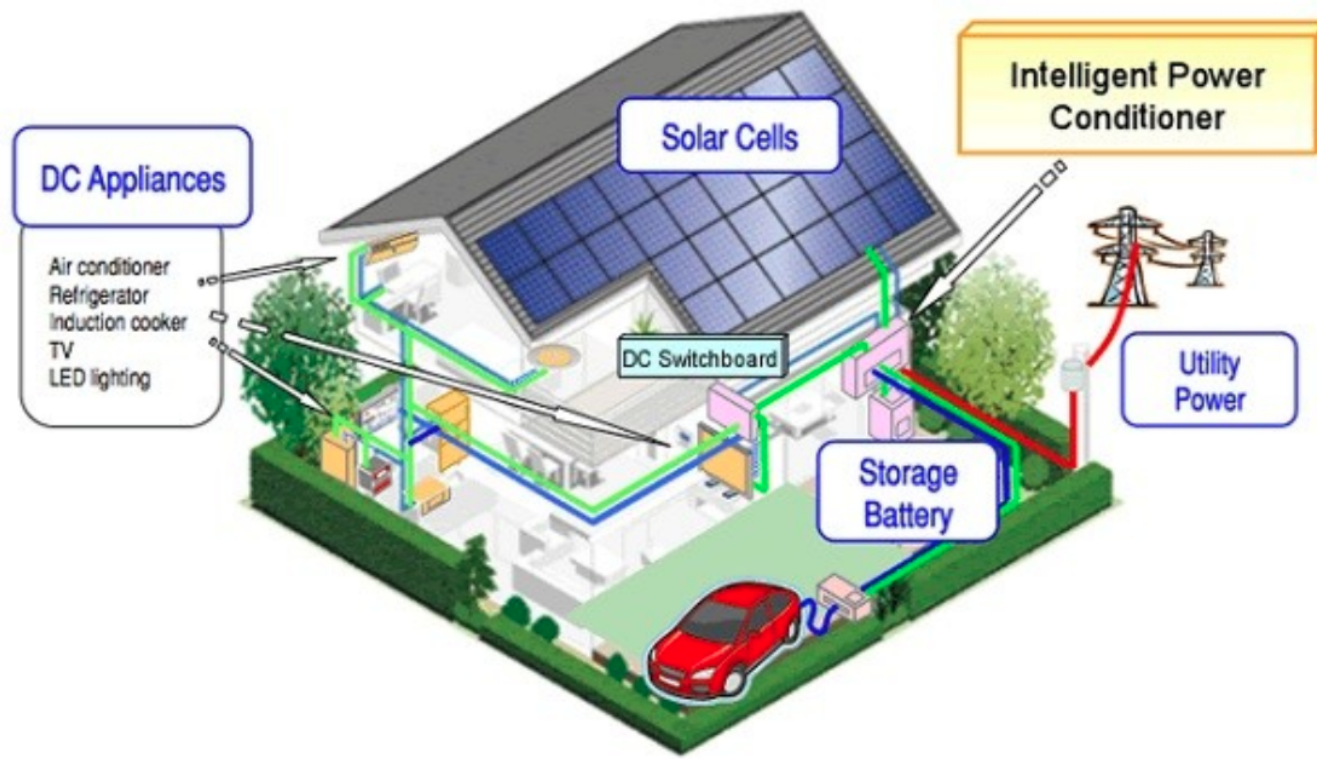


# Private industry is seeing opportunities

Sharp's Intelligent Power Conditioner works with EVs to make your house a lean, mean, solar-powered machine

By **Michael Gorman** posted Feb 23rd, 2011 at 1:13 PM

0



*Efficient DC end-use technologies are particularly enabling....*

# Thinking about deployment partners

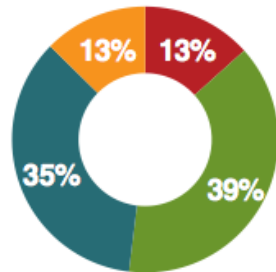
- **Resiliency advocates** have a hard sell...  
.... for much the same reasons as do energy efficiency advocates
  - Recognizing synergisms could help all parties
  - Non-energy benefits
  - Resilience community its own, different concept of performance
  - Already in their own deployment mode (labels, standards, etc.)
- **Building code developers** stovepipe resilience and building energy performance, but could integrate
- **Green buildings advocates** are a bit schitzo about resilience, although there is no intrinsic dilemma
- **Utilities** have clear interest in both angles
- **Insurers** care about climate-change adaptation and mitigation co-benefits, and can incentivize better practices



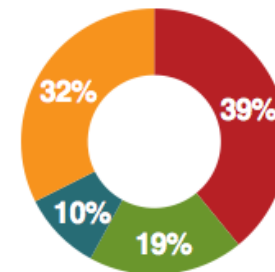
# Insurance: disasters through their lens

## Global natural catastrophe events: 1980-2012

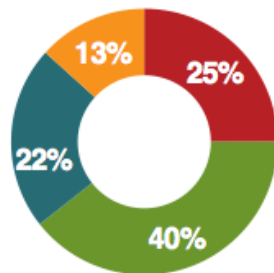
21,000 Loss events



2,300,000 Fatalities

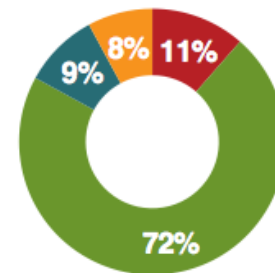


Overall losses\* US\$ 3,800bn



\*in 2012 values

Insured losses\* US\$ 970bn



\*in 2012 values

**Geophysical events**  
(Earthquake, tsunami,  
volcanic eruption)

**Meteorological events**  
(Storm)

**Hydrological events**  
(Flood, mass  
movement)

**Climatological events**  
(Extreme temperature,  
drought, forest fire)

# Insurance: precedents

- Resilience
  - Meso-scale modeling based on individual building forensics
  - Product testing/rating/labeling
  - Premium credits for resilient buildings
  - Lobbying for improved codes
- Efficiency
  - 57 companies offering 130 products & services
    - Premium credits
    - Upgrade-to-Green contract amendments
    - Liability insurance for RESNET auditors



# Insurance: partnerships

- World's largest industry – but have limited bandwidth
- They direct and fund 100's of \$billions each year in capital replacement and reconstruction (“claims”)
- They have things to teach us about risk assessment and management
- Controlling losses helps maintain insurability and affordability for consumers; also reduces public burden
- Many of the innovations we've documented were carried out in partnership with non-insurer entities
- Public insurers of private infrastructure (e.g., FEMA) as well as publicly owned infrastructure (e.g., HUD, DOD) should be at the table as well



# Take-homes

- Resilience is a good “hook” for efficiency (and *visa-versa*)
- Many natural partners for EERE
- The building (energy/indoor environment) performance community has many useful things to offer to the resilience community
- Multiple potential deployment partnerships (public and private)
- Let’s not allow this to be another passing fad
- Open frontier for RD&D – proposed LDRD @ LBNL to explore these avenues further

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